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MINE ROCK DISPLACEMENT AND REDUCTION OF COAL LOSSES IN THE MOSCOW BASIN

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Observations on surface displacement caused by mining operations have been conducted in the Moscow basin since 1932. The coal seam here is 35-70 meters from the surface and the overlying rock consists of loose sands, sandy and soft clays, and limestones.

On the basis of observations made from 1932 to 1938 the extent of surface displacement was established, and "Regulations for Protecting Surface Installations from Damage due to Mining Operations in the Moscow Basin" were worked out. At this time only relatively dry, high-quality coal deposits were being worked. By 1945 - 1946 when operations were begun in wet deposits which had loose sand in the roof of the seam, it was necessary to determine whether the rock displacement in these new conditions would be the same as in the previous workings. Observation stations which consisted of two longitudinal and three or four lateral cross sections were set up with a concentration of observation points in zones where displacement had ceased in greatly flooded mines, Mine No 26 and 30 of the Donskoyugol' Trust and Mine No 32 of the Krasnoarmeyskugol' Trust.

When clay and clayey soil predominate in the overburden and there is only a small content of sand and limestone as in Mine No 26, the angle of cave-in (ugol obrusheniya) and subsidence (osedaniye) is considerably higher (5 - 8 degrees) than when a large percentage of limestone sand, 12 - 27 or even 30 percent, is found in the overburden.

The angle of cave-in, which determines the limits of the danger zone for surface installations, is 9 - 14 degrees less than the angles of subsidence and displacement (sdvizheniye).

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In spite of varied geological and operational conditions, the process of subsidence goes on almost uniformly. When the working face is being advanced without interruption, slight surface subsidence is noticed at a point on the surface 20 to 30 days before mining operations are directly below it, and the rate of subsidence increases gradually. During the 10 days when the mining operations are being carried on below this section of the surface, or 10 days later, the rate of subsidence reaches its peak and then starts to decrease gradually, until it ceases altogether after $1\frac{1}{2}$ - 3 months.

Intense subsidence continues in some areas for 20 days to 2 months depending mainly, as does the entire subsidence process, on the speed of the advance of the mine face. The faster the mine face is advanced the more intense the subsidence and the sooner this process is finished.

Of 24 houses constructed in areas under which mining had been carried on there were only two cases where the structures showed a slight deformation when the interval between mining and construction was 2 months. Observations show that subsidence ceases not later than 3 months after the end of mining operations.

Subsidence amounts to 70 - 90 percent of the extracted thickness, and on the surface reaches 2.5 meters at the center of the depression, decreasing towards the edges. The contour of this undermined area changes considerably and water must be drained and the surface leveled before building.

Observations showed:

1. The following angles of cave-in must be expected:

a. From 70 to 73 degrees for overburden in which clay and clayey soil predominate, with a small content of limestone, e.q., Mine No 26.

b. From 75 to 78 decrees for overburden which contains a considerable part, over 10 percent, of limestone, even with a large content of water-bearing sands, e.q., Mine No 30 and 32.

2. Angles of subsidence with a 20-millimeter minimum of settling and angles of displacement with a 30-millimeter displacement are approximately equal. They differe 1.5 - 2 degrees and constitute:

a. About 60 - 62 degrees, average 61 degrees, in overburden mainly composed of clay and clay soil with a negligible limestone content, e.q., Mine No 26.

b. About 63 - 67 degrees, average 65 degrees, where the overburden contains 10 percent or more limestone and a large quantity of water-bearing sand, e.q. Mine No 30 and 32.

3. To reduce coal losses in pillars under protected surface installations it is necessary to change the angles established by "Regulations," and to build pillars for buildings of the first category under a 55-degree angle and for buildings of the second category under a 60-degree angle.

4. Twenty to thirty millimeters of displacement without breaks in the surface does not damage surface installations, such as highways, mining railroads, wooden and one-story stone houses and farm buildings. To protect these installations, safety pillars must be constructed at the angle of cave-in and not at the angle of displacement. Depending on the type of overburden, this angle will be 70 - 75 degrees.

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5. In mining areas worked by long pillars, only small one-story structures should be built after 3 months, and two-story stone buildings should not be built for at least a year after mining operations are completed.

6. As the angles of cave-in and displacement are changed by the condition of the overburden, surface subsidence should be observed for each single type of deposit for the composition of overburden.

Many instances of excavation of safety pillars left to conform to "Regulations" indicated that the danger zone of cave-in, i.e., appearance of small fissures, is far from the boundaries of the surface installations being protected. This shows that considerable coal supplies are being lost in excess pillars.

In three mines, No 15 of the Tovarkovugol' Trust and No 22-bis and 25 of the Oktyabr'ugol' Trust, part of the safety pillars of the drifts were excavated in 1942 - 1943 until fissures appeared in the immediate vicinity of the drift (stvol). The angle of cave-in here was 70 - 74 degrees.

In one of the mines of Donskoyugol' Trust the protective pillar under the railroad water supply system was reduced. The angle of cave-in was 72 degrees 30 minutes.

At another mine a railroad intersects the mine field for a distance of 1.5 kilometers. It was necessary to construct safety pillars under this railroad. The angle of cave-in with the approach of mining operations to the railroad (appearance of fissures) was determined to be 65 degrees 24 minutes. Safety pillars were built at this angle and not at the 55 degree angle suggested by the "Regulations."

Observation and generalization from experience led to the recommendation and practice of constructing safety pillars under mine railroads, highways, water system mines, water pipes, and one-story dwellings at an angle of 65 - 70 degrees. As a result of this, coal losses under railroads and highways decreased 600,000 tons during 1947 and 1948, and 200,000 tons were saved in the drifts themselves.

In the Moscow Basin there are many mines under surface ravines and valleys which account for considerable water seepage in the spring and relatively little in summer and winter. Mining under these ravines and valleys depends on the composition and depth of the overburden. When the coal seam is at least 25 meters below the water-collecting depression and there is a layer of 8 to 10 meters of soft clay above it, mining operations can be carried out under the depression, even in spring, without danger of flooding the mine. If fissures and cracks which are formed before the snow melts in the valleys are plugged and tamped with clay, straw, and manure, water does not penetrate the mine.

When sands and especially limestone predominate in the overburden, water seepage holds up mining operations; they can be carried on only during the summer, and then with artificial drainage. Only the longwall system can be used. Worked-out areas are artificially collapsed without leaving pillars in unexhausted sections of the drifts, thus preventing craters from suddenly appearing on the surface at later dates. Cracks and craters which are formed on the surface must be carefully filled and tamped.

When the coal seam is only 10 - 15 meters under a water-collecting depression and the overburden consists of porous rock and sand, and considerable water penetrates the seam during the spring, it is best under these conditions to stop mining operations and to leave safety pillars.

At the principal mines, 10- to 40-meter safety pillars are left. According to the Regulations of Technical Operations, the safety pillars should be 40 meters, but to decrease coal losses, it would be expedient to leave some 10 - 12-meter pillars.

The composition of the overburden should be the main factor in determining the size of the safety pillars. The three following types are characteristic of the Moscow area.

The heavy roof includes in the immediate roof compact clay more than 3 meters thick or sandy clayer rock more than 50 percent clay. By immediate roof is meant the distance from the coal seam to the nearest limestone. In the heavy roof this distance is not more than 3 or 4 times the thickness of the seam. A distinguishing feature of the heavy roof is the constant heavy overhead pressure which crushes props and makes artificial caving difficult.

The medium roof has a layer of less compact clay 1 - 2.5 meters thick above which is a layer of sand or clayer sandy rock with a 25 - 50 percent clay content. The distance between the coal seam and the limestone is 4 - 8 times the thickness of the seam.

There is little overhead pressure in the light roof, the pillars are only slightly deformed and artificial caving is easily carried out. The overburden consists of clay one meter thick with a layer of easily caved rock within the limits of the immediate roof.

Observations show:

1. As a rule, 40-meter pillars are adequate for any mine with the exception of those with the heaviest roofs e.q., Mine No 30,

2. Pillars 35- to 40-meters should be adequate for mines with compact clay, i.e. heavy roof, in the overburden,

3. In mines with dry or slightly damp sands, i.e. medium or light roof, or with sandy light clays, 25- to 30-meter safety pillars should suffice,

4. Less than 20-meter safety pillars are not enough to prevent deformation over a long period of time under any conditions, heavy, light, or medium roof,

5. It is necessary to avoid cutting through the pillars in the mining operations since even 40-meter pillars are not then capable of protecting the drift from deformation and cave-ins.

6. When limestone is close to the roof, it is difficult to decrease the size of the pillars, since the pressure of the overburden is greater than when limestone is farther.

In saving coal, the partial extraction of interface pillars is very important. At present the amount of coal left in these interface pillars does not conform to existing conditions. They should be 12 meters wide under heavy roof conditions, 9 meters under medium roof conditions, and 8 meters under the dry, light roof conditions.

Significant quantities of coal have been saved by reducing interface pillars to these dimensions.

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